Effect of Calcium on Uranium (IV) Uptake by *Brassica juncea* Under Circumneutral pH

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Objectives

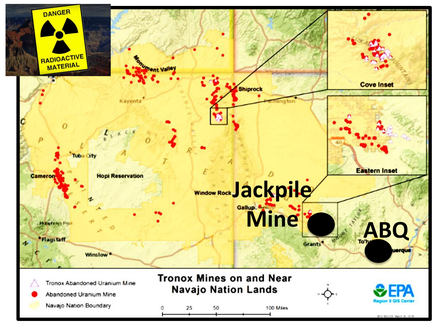
Investigate the potential of *Brassica juncea* for U (VI) uptake under environmental conditions relevant to the Jackpile mine, Laguna Pueblo, New Mexico, using a combination of controlled hydroponic experiments and spectroscopic analyses.

Motivation

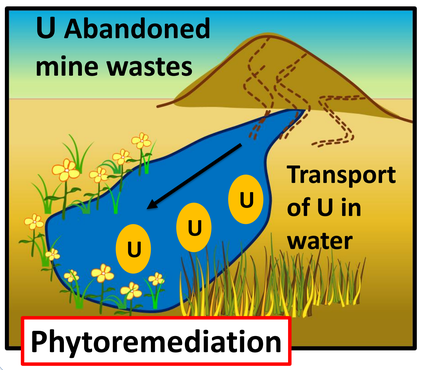
The mining and processing of U has left a legacy of contamination that is concerning to affected communities due to potential ecological and health risks. Although it is known that U can hyper-accumulate in plants such as *Brassica juncea,* we have limited knowledge about the specific mechanisms affecting U bioaccumulation under environmentally relevant conditions.

Background

Abandoned mine sites in the southwestern USA



The New Mexico, Laguna Pueblo, Jackpile Mine



Field measurements at Jackpile Mine

Water	U ($\mu g.L^{-1}$)	35.3-711
	pH	7.5-7.9
	Ca (mM)	0.2-6.9
Sediments U ($mg.Kg^{-1}$)		3.7-12.4
Plants roots U ($mg.Kg^{-1}$)		2.6-21.3

Materials and Methods

1-Preparation of *Brassica* seedlings

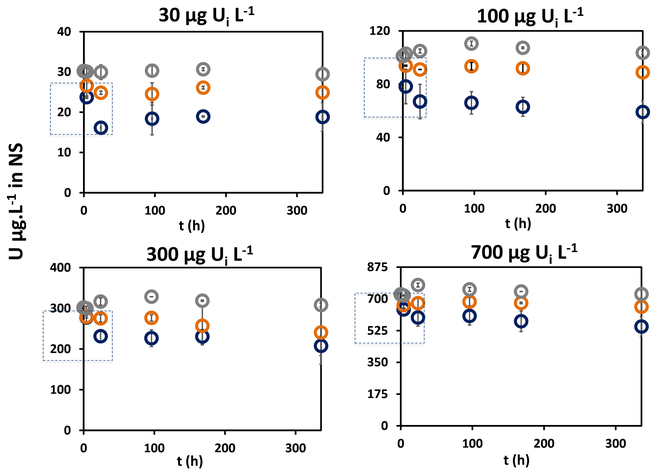
2-*Brassica* Exposure to U

Experiments were conducted in water (Nutrient Solution "NS") containing 1mM HCO_3^- under controlled pH (7.5) and Calcium (Ca) concentrations (0.3-6 mM) over a range of U concentration (30-700 µg/L) relevant to Jackpile Mine, Laguna Pueblo, NM.

NS composition: $MgSO_4$ 0.5mM, NH_4NO_3 2mM, KCl 1mM

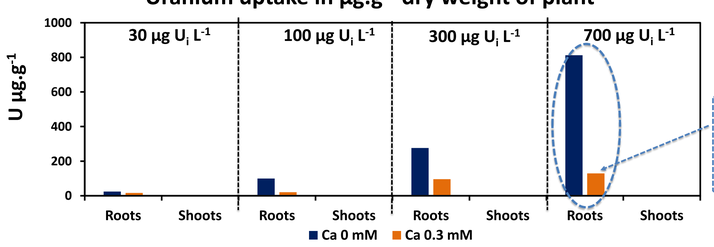
Results and Discussions

Variation of U in $\mu g.L^{-1}$ in Nutrient Solution "NS" over time



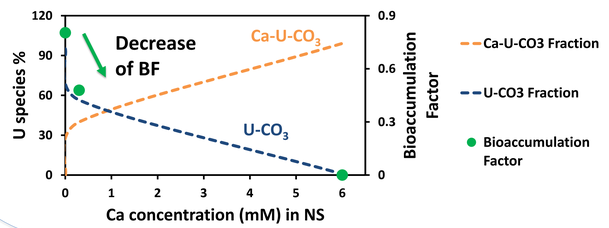
Fast U removal in the first 24 hours:
17-47 % when water contains no Ca
7-18 % U removal when Ca=0.3 mM
And no measurable removal at 6 mM Ca

Uranium uptake in $\mu g.g^{-1}$ dry weight of plant



The uptake of U is only detected in the roots.

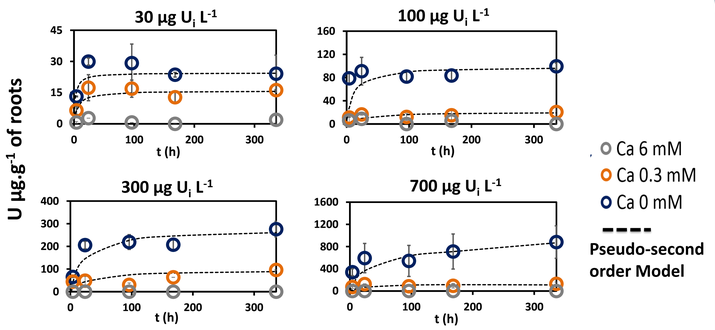
Why are we seeing decrease in U uptake by plants roots when Ca increases?



When Ca-U-CO_3 fraction becomes the dominant aqueous species of U, the Bioaccumulation Factor (BF) in *Brassica* roots becomes almost zero

Results and Discussions

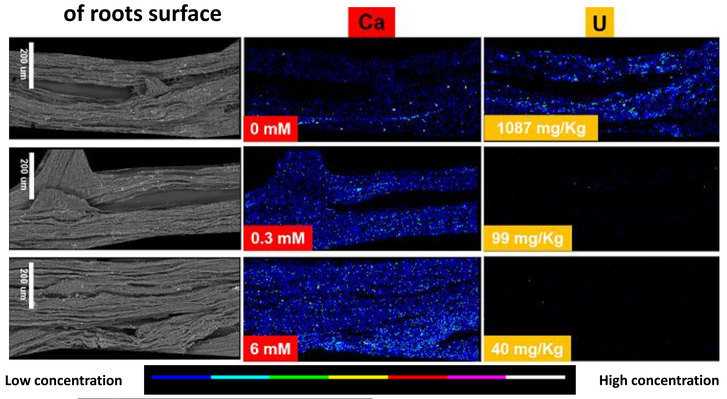
U uptake in $\mu g.g^{-1}$ dry weight of roots over time

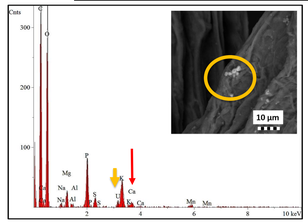


Uranium Uptake rates following pseudo-second order kinetics likely attributed to bio-sorption/precipitation mechanisms. For Ca 0 mM, the initial sorption rate (V_0) ranged from 4.4 to 62 $\mu g.g^{-1}.h^{-1}$, while for Ca 0.3 mM, V_0 ranged from 0.73 to 2.07 $\mu g.g^{-1}.h^{-1}$. No measurable uptake rate at 6 mM Ca.

Microscopic observation of roots surface

Microprobe mapping





Microscopic U particles were detected at the surface of the roots

Conclusions

This study shows how Ca and HCO_3^- in water at circumneutral pH can inhibit the bioavailability of U in plant roots due to the presence of ternary uranyl-carbonate complexes.

The results from this study are relevant to applications related to phytoremediation of mining legacy sites.